A Space in Time

Click for the universe … Your home computer, thanks to the windows that NASA has poked in space, is the site of the greatest show on earth. A deskbound cosmic pilgrim beckons us to an available sublimity

By Michael Benson

July/August 2002 Atlantic Magazine
Also published in ***Beyond: Visions of the Interplanetary Probes*** (Abrams, 2003)

In the evenings, when my particular piece of Earth has turned away from the Sun, and is exposed instead to the rest of the cosmos, I sit in front of a keyboard, log on, and seek out the windows that look down at the planets and out at the stars. It's a markedly different experience from looking at reproductions on paper. What I see is closer to the source. In fact, it's indistinguishable from the source. These are images that have never registered on a negative. Like the Internet itself, they are products of a digitized era. Over the past couple of years I've been monitoring the long rectangular strips of Martian surface being beamed across the void, in a steady stream of zeroes and ones, from the umbrella-shaped high-gain antenna of the Mars Global Surveyor spacecraft. These pictures are so fresh that their immediacy practically crackles. Call it "chrono-clarity." That bluish wispy cloud, for example, hovering over the Hecates Tholus volcano, which rears above the pockmarked surface of the Elysium Volcanic Region in the Martian eastern hemisphere—it has barely had time to disperse before I, or anyone with Internet access, can see it in all its spooky beauty. The volcano emerges from the pink Martian desert, which looks organic and impressionable—like human skin, or the surface of a clay pot before firing. The tenuous cloud floats near the volcano's mouth, as if in prelude to an eruption. It's a picture composed of millions of dots and dashes of data, produced by a transmission technique just a few steps removed from Morse code; but it reveals a landscape the likes of which Samuel Morse, let alone the ranks of Earth-based astronomers who have surveyed the planets since well before Babylonian times, could scarcely have envisioned.

In case there was any doubt, many of those good old science-fiction predictions from the 1950s and the 1960s are coming true. "NEW SQUAD OF ROBOTS READY TO ASSAULT MARS" read a 1998 headline in the online Houston Chronicle, stirring submerged memories of my adolescent readings of Isaac Asimov's I, Robot stories. But Asimov's sentient robots were frequently confused. Something always seemed to be going wrong with them, and the mayhem that followed could inevitably be traced back to a programming error by their human handlers—a situation not unfamiliar to those running NASA's Mars program, which was temporarily grounded after a catastrophic pair of failures in late 1999. (The Mars Climate Orbiter was lost owing to the stark failure by one group of engineers to translate another group's figures into metric units of measurement, and the Mars Polar Lander because for some unfathomable reason its landing gear hadn't been adequately tested.)

For all their formidable prescience, Asimov and his contemporaries Arthur C. Clarke and Robert Heinlein didn't quite conjure up that still-startling compound of populist forum, deep archive, and global amphitheater called the Internet. I picture a packed arena of Romans, teeming and kaleidoscopic, at the height of the empire. They're savoring the gods'-eye view, watching the Red Planet turn. Would they have seen it as territory to conquer? Would they have sent in the legions? Mars, after all, was named after the Roman god of war, the father of Romulus and Remus. And what about our age—which way, in the end, will we go? "Earth is the cradle of the mind," said the pioneering Russian space-flight theorist Konstantin Tsiolkovsky. "But we cannot live in a cradle forever."

A low hum resounds from the tiny fan recessed in my computer—a propeller venting warmth from the machinery of virtual travel. With rusty Martian sand dunes still undulating across the screen, I notice that outside, the Moon is rising over subzero Central Europe. The city below it is quiet, subdued under snow. Beyond brick smokestacks a familiar cool light defines the icy sphere. A ghostly mass of battered rock, Earth's satellite is an archetypal solar-system object, with surface features echoing those of many of the planets and moons arrayed in far-flung archipelagos around the Sun. But it's much more than that—at least in the human context. The longer one considers it, the more its tidal influence grows. Without that luminescent lure would there even have been a pull to leave this planet?

Deciding to take a closer look, I accelerate away from Mars and shoot thirty years into the past—descending rapidly through the strata of the Apollo archives. I quickly find an excellent picture of a three-quarters moon, taken by a large-format mapping camera during one of the later manned missions, in the early 1970s. Almost the entire ravaged face is visible, with tactile gradations of surface texture readily apparent—craters edging gradually toward the terminator, that endlessly migratory line between day and night, and into darkness. There's a three-dimensional, convex quality to the image. But it looks somehow odd. I realize that I'm looking down at a lunar surface divided between the side always oriented toward Earth—the face with a face, so to speak—and the far side. Two of the familiar eastern mares, or seas, are situated here on the left side of the picture—in the hemisphere visible from Earth. On the right, facing deep space, well east of the immense circular basin of Mare Crisium, the battered back of the Moon is submerged in elongated shadows.

Suddenly, with a kind of vertigo, I sense the home planet, way off past the left border of the picture—and even myself, somewhere down there, at the age of ten, maybe looking up at the exact moment the shutter fell on Apollo 16. I'm frozen in that same clockwork flux generated by the spheres as they move inexorably through space. Looking out the window again (here, now, a traveler on a winter's night), I realize that the Moon is in exactly the same phase.

Between self, screen, and window, a kind of temporal triangulation. And what am I doing now, if not the same thing as then? Looking up, "just" in time.

When I return to Earth, it's always to Ljubljana. As far as most of my New York friends are concerned, I already live in outer space. Slovenia has never exactly been at the center of things. It's not even at the center of that nebulous interzone called Central Europe. I came to this tiny nation of two million alpine Slavs shortly after its dangerous secession from Yugoslavia, in the summer of 1991. Ten days of intermittent, partisan-style war against the federal army had devolved into an uneasy cease-fire, periodically shattered by the rolling kettle-drum crash of MiGs breaking the sound barrier overhead. But the army soon withdrew, rumbling southeast toward Croatia and Bosnia, with a kind of murderous, humiliated gleam in its eye. It left behind an independent—and remarkably unscathed—new country.

I moved to this fringe of the disastrous Balkans to make a film. When I finally finished, four years later, I remained based in Hapsburg-perfect Ljubljana while I took the resulting movie—called Predictions of Fire—to festivals all over the world. Meanwhile, I got involved in various projects and lives. Then I got married—and eventually had a son. The time never seemed right to move back to New York. Without quite realizing it, I had become an expatriate.

But it didn't take me long to discover that it was possible to go even further out. In the spring of 1995, on the early color monitor of a used IBM clone, the World Wide Web blinked to life on my desktop for the first time. I quickly proceeded past the novelty of being able to read The New York Times while most of Manhattan slept, and discovered a way of looking through the "windows" of crewless spacecraft—vessels that have seen Earth dwindle to the size of a pearl, and then a pixel, as they voyaged far beyond any place ever directly observed by human beings. Very far beyond.

It takes only the briefest of Net-mediated shunts, in other words, to vault from the slate-gray drainpipes and cracked flagstones of Vrhovceva Street No. 4 and through the open window of escape velocity—25,000 miles per hour. The procedure is silent, with none of the countdown, dazzle, and roar we associate with rocket propulsion. But it works flawlessly nonetheless. And once one has escaped Earth's gravity, the universe unfolds, revealing vistas across space and time so multifaceted, so replete with the unlikely, the mysterious, and the awe-inspiring, that it's astonishing that the whole procedure can be channeled through the good offices of a local phone call.

Suddenly, on the screen as in reality, I saw the whole story—the human and even the post-human story—delineated against a vast, starry black backdrop. Forget the astronauts, marooned in low Earth orbit for three decades. A continual remote-controlled extension of boundaries is under way. Intricate space probes—encased in scarabaeoid shells, festooned with scopes and scanners, and driven by solar-powered cells and radio-isotope thermo-electric generators—are redefining the limits of human knowledge. Deployed at the perimeter, they're casting wide-eyed glances and making sophisticated measurements, well past any terra incognita where sea monsters once seethed through oceans pouring off the rim of a flat planet.

Pretty soon I was hooked. I began compulsively monitoring the progress of our space-faring machines.

That moon, rising implacably over Ljubljana, has long since ceded center stage. It defined the first act, but now it's a cameo, backlit by the immense universe beyond. It played its role well, though, using its small gravitational field to full advantage, gradually reeling the species off Earth to have a look around. At the beginning of the fifth decade of space travel the various tools for that investigation have increased their power in exponential jumps. What they're looking at is astonishing in its depth and diversity.

NASA's Jet Propulsion Laboratory, which is in charge of all American unmanned missions, is keeping tabs on a record number of space probes these days. They include the joint NASA-European Space Agency solar observatory, which has been producing amazing stop-motion films of quakes and tornadoes on the Sun for more than six years now, and the giant two-story spacecraft Cassini, which has been threading a circuitous course toward Saturn ever since its launch, in October of 1997. Cassini swung past Venus twice, picking up gravity-assisted momentum each time, and then boomeranged around Earth again on its seven-year flight to the ringed planet. On January 1 of last year the probe sent home one of the most beautiful color photographs ever taken of Jupiter and its companion moon Io. A behemoth compared with most of the other new probes, Cassini was designed well before the advent of the "faster, better, cheaper" doctrine that the former NASA administrator Daniel S. Goldin introduced, with some fanfare, in the early 1990s. This low-budget management philosophy, seemingly not applicable to the half-billion-per-blastoff space shuttle, let alone the financially troubled International Space Station, requires that spacecraft cost less than $150 million and go from the drawing board to the launch pad in thirty-six months or less. It has been under heavy bureaucratic scrutiny recently, owing to the loss of those two Mars probes in 1999.

Still, NASA's Discovery-class missions were run according to this doctrine, and the program has racked up some real successes. They include Global Surveyor, which recently completed a photographic map of the Red Planet to rival the best we have of Earth, and Pathfinder, which created something of a media sensation back in 1997. Pathfinder bounced down on the Martian surface using a set of inflated air bags, the first time such a landing method had been attempted. It then opened its multiple petals like a mechanized flower and proceeded to roll out a telegenic, insectoid little rover named Sojourner—without a doubt the most charismatic unmanned vehicle in NASA history.

In early 2000, in an event largely ignored by the mainstream media, the Jet Propulsion Laboratory eased a Discovery probe called NEAR (for Near Earth Asteroid Rendezvous) into orbit around a twenty-one-mile-long peanut-shaped, methodically tumbling rock called Eros. NEAR was the first spacecraft ever to orbit an asteroid—no inconsiderable feat of celestial navigation, given that Eros has a gravity field so weak that an astronaut on its surface could reach escape velocity by simply jumping off. A year later project scientists maneuvered the probe to within a few hundred yards of its subject and then directed it to touch down gently. NEAR thus became the first spacecraft to land on an asteroid.

NEAR hasn't performed flawlessly. Not unlike an adolescent confronting the object of his or her erotic fascination for the first time, the spacecraft suddenly flipped out during its initial approach to Eros, in December of 1998. Cut off from communication with Earth, acting on its own, the probe's computer managed to re-orient the spinning craft. But by the time the JPL flight engineers had figured out what went wrong, they were forced to send their charge all the way around the Sun again—a year-long trajectory—for another try.

They wouldn't have been able to do so if NEAR hadn't straightened up and flown right all by itself. There's something fascinating about the increasing autonomy of these robots with which we're populating the heavens. In late fall an e-mail came to me from the JPL—something again automatic, sent through that other universe, the one made of innumerable routers and chips. It announced the launch of the first unmanned spacecraft capable of making many of its own decisions regarding its orientation vis-à-vis Earth. The phrasing itself was intriguing—even if we were not yet talking about political orientation. If I didn't know better, I might have begun to suspect that a kind of baton-passing was taking place, far beyond the atmosphere. From flesh-and-blood us to nuts-and-bolts them. Science fiction?

Sifting through a self-congratulatory final press release archived at the Mars Pathfinder site, I was suddenly, unexpectedly, moved. Contact with the lander was lost, it said, in early October of 1997. That was after nearly three months of continuous operation—much longer than expected. The loss of communication was attributed to the failure of the lander's battery, which in turn cut power to the heater. "After that," the text read, "the lander would begin getting colder at night and go through much deeper day-night thermal cycles. Eventually, the cold or the cycling would probably render the lander inoperable."

But little Sojourner is almost entirely solar-powered. It was just as animated as ever when all contact with Earth was lost. I came across the following sentence: "The health and status of the rover is ... unknown, but ... it is probably circling the vicinity of the lander, attempting to communicate with it."

The poignancy of it! The pathos! Powered forever by the inexhaustible Sun, impervious to the cold, Sojourner may to this day be wearing grooves in that ocherous desert floor. And we've forgotten our cybernetic creation, literally leaving it to its own devices. Having chipped, hammered, glued, and then welded and screwed together the matter we're surrounded with, we've finally endowed it with eyes, ears, and a capacity for self-direction—something like early life itself. We've propelled it at extreme velocities to distances that redefine how far human artifacts can go. And we've left it to circle, or even to beeline out of the solar system—still seeking orders, still trying to communicate with us.

A few years ago I happened to be scrolling along the bone-dry branchings of a newly discovered Martian riverbed when a small headline started winking on and off like an insistent neon sign, advertising a live feed of the Mars Polar Lander launch. I steered my arrow over to the Real Player icon next to it and clicked. A simulated TV set unfolded itself, voilà, in the browser window. The thing was approximately the size of a matchbox. From the virtuality of television to the next stage: the TV itself becomes virtual. This miniature screen-within-a-screen filled with what appeared to be a close-up of Earth's surface: not grass and soil, or the heaving Pacific, but staggered gray concrete and an elaborate web of girders, ramps, and drifting smoke. Evidently the camera was mounted on the lower stage of a rocket. I was looking directly down at Cape Canaveral launch pad 17B.

A tinny countdown issued forth from my computer's speakers, and I watched the grainy yet kinetic, comically Lilliputian live launch of that ill-fated robotic mission. Tongues of bright-orange flame flared out, filling the bottom of my stamp-flat TV. The ground rushed away, rapidly becoming coastline and then cloudscape. I clicked on the magnifying-glass icon to enlarge the toy picture, which expanded to fill half the screen. The image now verged on abstraction, a scramble of "compression protocols" trying frantically to keep up with the fast-paced reality of a rocket blasting through the sound barrier and out of the atmosphere just like that. The arc of Earth's limb appeared—immediately recognizable, as if coded in ancestral memory. Sixty-six seconds after liftoff four pencil-shaped solid-fuel boosters separated from the Delta II rocket and fell gracefully away, trailing streamers of smoke as they spiraled back toward Florida. The curved horizon was defined by the inky blackness of space.

Ironically, this image of our home planet had a far lower resolution than do the crisp pictures Surveyor has been wiring back from Mars. That's because time had been added to space; it was, at least nominally, a motion picture, and a live one at that. Fascinated by this example of technique chasing technology, of software trailing hardware, I watched our pixelated planet, a spinning blue globe forced continually to reassemble itself as blocks of Atlantic cloud moved lumpily forward. Data coursed through the modem with a barely discernible thrumming sound, something like the brrrrrr of a hummingbird's wings. Four and a half minutes into the flight the horizon suddenly rose again, now in a free-wheeling spin. The lower stage of the rocket—the one with the camera—had fallen away. Then there was nothing but micro-miniaturized TV static: "snow" twice removed. The probe would soon reach escape velocity. The feed was over. We human beings had been left far behind. Not for the first time.

Stubbornly refusing re-entry to Earth, I raced ahead of the new probe to Mars orbit again, where I looked down at the grandest canyon in the solar system—a jagged 2,500-mile-long gash that could easily span most of the continental United States. This is Valles Marineris, named after its discoverer, the 1971 Mariner 9 probe. In the past five years Surveyor has zoomed up close on the eroded rim of this immense canyon, which at points is more than six miles deep. The resolution of these pictures is so good that scientists could easily spot, say, a small concession stand set up at the rim of Noctis Labyrinthus, the complex series of connected rift valleys defining the canyon's western periphery. Coke? Fries? Oxygen? Huge ancient river channels begin from Valles Marineris and run north. Many of them lead to the boulder-strewn floodplains of Chryse Basin—the landing site of both Viking 1, which set down in 1976, and Pathfinder, which bounced to a halt, beach-ball style, some twenty years later.

I scrutinized the image produced as Surveyor moved across the canyon's northern edge. A small impact crater was clearly visible near the rim, as perfect as a drop of rainwater captured a split second after hitting a lake. Although this area otherwise looks as dry as dust, in April and May of 2000 startling images of the Gorgonum Chaos region in the Martian southern hemisphere revealed what appeared to be recently formed gullies snaking through twisted terrain. Indistinguishable from similar formations on Earth, of the kind that form always and only above groundwater, they seem to indicate an aquifer only a few hundred yards beneath the surface.

And this, of course, is not something one scribbles furtively at the end of a paragraph, hoping nobody will notice. After hundreds of years of fruitless observation from Earth, followed by three decades of robot flybys, orbiters, and three successful remote landings on the surface, it took the eagle-eyed, low-budget Global Surveyor to finally divine water on Mars. Eureka!

Gazing down at the luminous buttes and mesas of Valles Marineris, an almost familiar landscape creepy in its emptiness of even the faintest flicker of life, I remembered driving in the summer of 1996 from Arizona's Meteor Crater—the best-preserved impact crater on Earth—to the edge of the Grand Canyon: a place where the Europeans settling the New World came face to face for the first time with a geological past so deep that it called biblical chronology into question. One reason the Grand Canyon became so symbolically important to the United States was that it served as a geologically eloquent stand-in for the young country's missing cultural history. (Native Americans, of course, didn't figure.) I wonder if it's a coincidence that this nation—now able to boast the longest continuous form of government on Earth—is centuries later expending the effort and resources to explore new, even more spectacular places where nature bears no trace of human history.

Nature, they say, abhors a vacuum. But the reference is really to humanity, always rushing in with its gizmos and interpretations. Maybe the serrated walls of that Martian canyon exist as an antipode to the ones in Arizona. Maybe that chasm at the center of American iconography is mirrored from above by Valles Marineris—a place signifying not a country's past but its future. Not the last frontier but the next one.

Probably the fact that I've moved around the globe for much of a lifetime has encouraged my tendency to place things in a cosmic perspective. Reportedly, the handful of astronauts who bounced across the Moon thirty years ago could sense, even at ground level, that they were on a sphere. The horizon looked too close. It also sloped downward, subtly but visibly, in a strange and airless clarity. Being raised in a Foreign Service family, as I was, can produce a similar effect on this planet. Give yourself a multiplicity of camera angles, in enough time zones, and eventually the sky becomes the sole common denominator.

A chain of cities unreels in my memory like a roll of archival film. I rewind to Ankara, Turkey, in the mid-seventies: An acrid pall shrouds the minarets. The city has some of the worst air pollution on Earth. Each room of our large house has an electrostatic air-cleaner; an army of plastic wood-grained boxes tries mightily to zap particulates before they reach our soft American lungs. But this brown haze is winter coal smoke. In the spring the stars blink and wheel high over the Balgat hills, pristine and clear in the thin, dry Anatolian air. For my twelfth birthday I am given a telescope. Out on the darkened lawn I point this tube—a device practically indistinguishable from the one Galileo Galilei built in the winter of 1609—up at the glinting night sky. Like that heretic Pisan, I rapidly discover a number of important things: The Moon is a cratered, mountainous body. The Milky Way is composed of innumerable individual stars. Jupiter, faintly striped, is attended by four stars—spread out in a thin line parallel to its bulging equator.

Several nights later I observe Jupiter again. Those "stars" have changed their positions, relative to the planet and to one another. They're the Galilean moons.

Nothing, however, prepares me for the sheer aesthetic pleasure of Saturn. How, in all creation, could such an object have come about? Clearly visible in their weightless tilt, as symmetrical as something made by the most precise of machine tools from the cleanest of mathematical models on the largest lathe in the galaxy, the multiple rings encircling this improbable object redefine what nature is capable of. Saturn is more beautiful than anything I have ever seen on Earth. It is a presentation, live and uncut, of cosmic perfection.

I pull eye from eyepiece and look down at the telescope's white barrel in amazement. Technology may produce a haze to choke cities. It may leak crude into the oceans. But it has also unveiled a universe made of glittering jewels.

Hurtling effortlessly along the cyberspaceways more than two decades later, I monitor blinking readouts and order micro-circuitry and interlinked telecommunications devices to navigate among the planets and the stars. Never before have such solitary, self-directed voyages into deep space been possible. Even the lunar explorers, those who actually broke free of Earth and traveled to another world, were slaves to their schedules and their uncompromising hierarchies of command. Opportunities to simply gaze out the window, to allow the experience to register in the soul, were few and far between. Many, when they returned, retained only sketchy, disembodied memories of what they had experienced. My journeys may not be actual, but they do give me plenty of time to mull over what I've seen through the portholes.

In May of 2001, a year definitively marked for space by Stanley Kubrick and Arthur C. Clarke in their film of the same name, I discovered that my personal space-exploration method had been validated by none other than the National Research Council, which recommended that an initial $60 million be allocated to create a "national virtual observatory." With the quantity of data that pours down from the sky growing ever more unmanageable, it seems that the old-style method of observation (in which astronomers, or kids on the lawn, point telescopes where they want to look) is gradually being replaced by something called data mining (in which researchers examine many layers of pre-recorded observations, frequently for the first time). With the Hubble Space Telescope alone downlinking more than two billion bytes a day, and with a higher-capacity next-generation space telescope being assembled in the wings, archives with the capacity to house hundreds of terabytes are necessary. When Cassini finally reaches Saturn, in 2004, its big high-gain antenna will start firehosing data down from the outer solar system at such a rate that the resulting flood will keep planetary scientists busy for generations. Despite unprecedented data-processing capabilities, they'll only be seining at the shores of the deep data ocean.

This outside-in, archival universe may be demanding all-new methodologies from the scientific classes, but it is also providing squinty-eyed tourists like me with more and more space to surf. With the Moon outside my frosted Ljubljana window now sliding well past its apex and descending toward the jagged Alps, I retrace the comet's tail of images produced by our distant robot explorers. The sheer number of these pictures, combined with the very high traveling speed of the cameras' platforms, creates a cinematic effect. This isn't a cathedral mosaic, arranged across a vaulted ceiling to make a composite narrative of heaven. It's a flipbook—film stills strung out in sequence along intricate trajectories, culled from some of the most hyperkinetic dolly shots ever devised.

In the past five years the almost frighteningly beautiful trove of Jupiter images sent to Earth by the hit-and-run Voyager probes of the late seventies has been dwarfed by reams of downloads from Galileo—a cybernetic descendant of its namesake that is currently orbiting within the complex Jovian system. Europa, one of the four moons discovered by Galileo in 1610, is particularly stunning. Reminiscent of the sentient ocean planet in the Russian director Andrei Tarkovsky's film Solaris (but frozen into bizarre, intricate patterns of fault lines, and "chaos terrain"), this haunting sphere of frosted off-white is surfaced entirely by branching, splintering, glittering ice. Although cue-ball smooth when viewed from afar, up close it presents a fascinating array of elliptical fissures and ridges—an Abstract Expressionist surface that practically demands decipherment. In 1999 Gregory V. Hoppa, the late Randy Tufts, and a team of planetary scientists from the University of Arizona went a long way toward cracking the code, positing that the most mysterious fault lines identifiable on Europa—the wave-form-like "arcuate" fractures spiraling eerily across the crystalline landscapes near its poles—are almost certainly a result of Jupiter's shifting tidal pull on subsurface water.

Only comparatively recently, in fact, have Europa's ramifications begun to register within the planetary-sciences community. The result is a cautious, gathering excitement: the moon has become one of the leading candidates as a host for extraterrestrial life. Some estimates hold that Europa contains five, even ten times as much water as Earth. Richard Terrile, of the Jet Propulsion Laboratory, put it this way to the press: "How often is an ocean discovered? The last one was the Pacific, by Balboa, and that was five hundred years ago."

As I continue hoarding pictures, I reflect on the freakish diversity of the solar system. To take only one example: Europa floats directly outside the orbit of a sister moon named Io, which is the most volcanic object in known space. This extraordinary fire-and-ice pair couldn't be more different. Io is orange, purple, greenish in places, and irreducibly strange. Squeezed by the huge hand of Jupiter's gravity, it erupts with dozens of hyperactive volcanoes that continuously spew plumes hundreds of miles into space. The volcanoes' magma, which at its source can be far hotter than any on Earth, rains back down on a constantly changing outer crust. In an ongoing inside-out heave, Io is continually replacing its exterior with its interior.

Drifting now past Saturn's shimmering rings, I see that they're aswarm with dust and large boulders, and that they abound in spokelike features and strange kinks—the former perhaps caused by electrostatic charges in the dusty, weightless debris, the latter by the gravitational pull of two small "shepherd" moons. Entire schools of theory have arisen to try to explain these complex, ever-shifting phenomena. Following the image trail to the farthest periphery of the solar system, to Uranus and Neptune, the most-distant planets ever visited by a space probe, I catalogue bizarre sights along the way. There's Miranda, the smallest of Uranus's major moons. This 290-miles-in-diameter object, named after Prospero's daughter in The Tempest, has huge faults twelve miles deep. In one provisional theory scientists speculate that it may have been repeatedly shattered by unknown forces, and then just as inexplicably reassembled, throughout its obscure history. Bleakly lit by the distant sun, floating in the ether, it may as well be the place fervently requested by tempest-tossed Gonzalo: "Would I give a thousand furlongs of sea, for an acre of barren ground."

Arriving finally at deep-blue Neptune, the end of the line, I look down at the sullen black storm that was its largest defining feature when Voyager 2 whipped past the planet in 1989. Called the Great Dark Spot, it's a whirling bruise the size of Earth, and it whistles with the strongest winds yet measured on any planet. South of it, out of sync, an irregularly shaped white cloud—endearingly named Scooter by Voyager scientists—scuds frenetically along the planet's equator at 1,200 miles per hour.

As I pass through the chill vacuum beyond the Earth-surveyed solar system, I cast a glance back at crescent Neptune and see that it reminds me of a work of art—something created by a master toward the end of a long career. There's a wintry virtuosity at play, combined with a palpable absence of any need to show off. Gone are the flashy excesses of Jupiter and Saturn. Neptune's rings are tenuous, almost invisible. Its haunting, cantaloupe-skinned moon Triton, one of the coldest places in known nature, is dark and inscrutable. Yet in spite of its deep-frozen state, activity is noticeable even here: plumes of carbon as black as squid ink emerge from cracks in its surface. Wafting upward, they're whipped suddenly into horizontal lines by some unseen hand. Below this startling scene, floating just above a blue vastness more unfathomable than any sea, a veil of wispy silver clouds is draped across Neptune's northern hemisphere.

Insomniac nights. I move on to interstellar and intergalactic space—to places capable of making even the most exotic views of the planets and moons seem ... local. These images are sent down by the orbiting Hubble Space Telescope. Ever since its initial embarrassing myopia was cured by five intricately choreographed space walks during a shuttle mission in 1993, the Hubble has been transmitting an electrifying series of observations—images capable of shocking even the most space-weary astronomer (or visual artist, or theologian, for that matter) into an awed silence.

In early 1996 astronomers fortunate enough to have a time-share arrangement on the Hubble observed what is surely the most apocalyptic sight ever viewed by human beings: two galaxies colliding headlong. A few weeks later, on my screen, I saw them—the Antennae galaxies, so named because of the pair of long, luminous "antennae" of disrupted stellar matter that extends out from their explosive center. It was a scene of almost unimaginable, orgiastic violence—yet quite serenely beautiful at the same time. Salted through the heart of this collision are more than a thousand young star clusters. This is a cataclysm so immense and distant that the stark fact of our ability to capture it, let alone understand it, seems capable of redefining our picture of ourselves. Where do we stand in relation to this stellar train wreck? It isn't some dream beyond death. In fact, it pre-dates our birth as a species. And yet we miraculously came along to produce this perfect simulacrum, this freeze-frame of smashing stars, and to bind it in a computer hard drive.

The stardust we're made of was produced by vast explosions not unlike these. It was only much later that the double helix—that genetic concatenation of biochemical triggers, derricks, and hoists—arrived to work the material. Sometimes I wonder what it says about our civilization that most people haven't noticed, or taken the trouble to really look at, the amazing cornucopia our sensors have been sending down from the heavens. Could the same secular era that produced these visionary machines be responsible for muting some of the awe that should presumably greet what they reveal? In investing them with a measure of soul and curiosity, have we lost an equivalent amount in ourselves? Maybe we just need more time. Or maybe, to put it another way, we need more space.

Honking out one of his trademark long lines, Allen Ginsberg put it well: the hipsters jittering through "Howl" burn for "the ancient heavenly connection to the starry dynamo in the machinery of night." Less hip, but just as motivated, Hubble's keepers tried an interesting experiment. From December 18 to 28, 1995, they focused on a place they assumed would have the least activity in it. Like a team of biologists bored with the ecstatic plenitude of life, like researchers dropping a blob of distilled water on a glass slide to see, finally, something without anything, they selected an area well above the cluttered plane of our galaxy and set the Hubble for the deepest focus possible. What they probed was an apparently empty quadrant in the vicinity of the Big Dipper's handle. The sampled segment—the deepest image ever taken of the heavens—covered, according to the official press release, "a speck of the sky only about the width of a dime located 75 feet away."

The faint beams of light from this tiny piece of space were painstakingly collected in 342 exposures over ten consecutive days. Cleaned up, processed, and digitally fused, these serial exposures finally came together to paint a picture not of an emptiness populated with a few feeble glow-worm photons but of a spectral woven carpet of galaxies seemingly reaching on and out forever, deep into space and time. About 1,500 venerable pinwheels and other galactic forms careen through the Hubble's cosmic "core sample," so faint they're undetectable by even the largest ground-based telescopes. Some of them at magnitude 30 are still four billion times fainter than that which can be seen by the unaided human eye. Called the Hubble Deep Field, the image gives vertiginous new meaning to the term "recorded history."

Selecting the highest-resolution file of this picture I can find, a sixty-seven-megabyte giant archived somewhere in England, I hit "load" and walk away from the apartment for four hours. Ljubljana on a winter's night: kamikaze drivers barrel through a dense, rolling fog. I look up at the sky; there's nothing there. Back in my apartment a laptop methodically assembles the galaxies.

When I finally return, through scrambled medieval streets and up creaking stairs, a vision from the edge of known reality fills my screen. Scrolling up and across, I try to understand. No, I finally decide, I'm not deceiving myself. This product of science is every bit as profound in its implications as the opening sentences of the Old Testament.

A while ago I sent a draft of this article to a friend in New York, the writer Lawrence Weschler (see "The Jewel of Poland," in this issue). He fired back a passage from Carl Sagan.

> In some respects, science has far surpassed religion in delivering awe. How is it that hardly any major religion has looked at science and concluded, "This is better than we thought! The universe is much bigger than our prophets said—grander, more subtle, more elegant. God must be even greater than we dreamed"? Instead they say, "No, no, no! My god is a little god, and I want him to stay that way." A religion, old or new, that stressed the magnificence of the universe as revealed by modern science might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths. Sooner or later, such a religion will emerge.

In the first known writing, Sumerian cuneiform, God was depicted as a star. Text and image, in other words, were once one. Five thousand years later the Hubble, a product of "pure" secular science, brings us full circle. It does so by looking far beyond any human language, spoken or written. About 10 billion years before the Sumerians the most distant—and therefore the oldest—galaxies visible in the Deep Field were still in the process of forming. They were doing so (in the picture they are still doing so, because the reddish light fired outward during their birth took that long to get here) "perhaps less than one billion years after the universe's birth in the Big Bang," according to the Space Telescope Science Institute.

Since that winter seven years ago, when the Deep Field image was assembled, space-telescope astronomers have concluded that no matter what seemingly vacant speck of space they deep-focus their cameras on, they'll inevitably find such an abundance of ancient, glinting fires. Trolling through these multicolored galaxies (the Deep Field image is so large that my screen can only sample a portion of it at a time), I shake my head. Clearly, science is producing iconographic images fraught with a kind of religious intensity. It does so by lengthening the border between what's visible (and therefore, at least provisionally, interpretable) and the ineffable beyond. This beyond deserves the term simply by definition. And as with any religious icon, or any work of visual art, the galaxies stacked up in the Hubble Deep Field are discernible in the first place because behind them is—darkness. Something undefined. A place—or, rather, an absence of place—that astronomers have named the Dark Zone.

This absolute darkness exists on the other side of the Big Bang. It pullulates its inscrutable energies before the Word. The ultimate nada, it provides a deep black backing canvas for the Beginning. In the presence of this supreme mystery, science, religion, and art all fuse into an etiological question without an answer. The English title for the first book of the Old Testament derives from Genesis kosmou, Greek for "origin of the cosmos." But the black backdrop beyond these earliest visible galaxies is a text we'll never be able to find the meaning of, written in an ink that has spread well beyond the margins of the page.

Suddenly I realize that I'm leaning forward, as if I were riding a motorcycle at a dangerously high rate of speed. My nose is only inches from the screen: if I hit a bump, I could vault right through—ending up in the distant past. Or am I already there, looking even further back? And how do you measure the nothing in nothing? How do you place something without anything in time and space when it's beyond both? A tension is set up—a vibration, as we almost grasp the ungraspable, and even have the hubris to put a frame around it. The ineffable presence of this absence calls to mind an observation by Novalis: "Philosophy is really homesickness, an urge to be at home everywhere. Where, then, are we going? Always to our home."

In the end, the Hubble's keepers found their emptiness in spades—their emptiness distilled. Above our heads the light cast off by all those impossibly distant galaxies continues to stream past. The fall of a goose feather is like a redwood crashing to earth by comparison.

As I log off, disengaging from that infinitely extended yet exquisitely detailed out there, it occurs to me that the sending of commands through cyberspace to unlock the images stored in these deep-space archives is a perfect analogue to the transmission and reception of data to and from our distant probes. The living, updated sites devoted to these cybernetic explorers are the link between inner and outer space, between the complex, growing, ever-changing web at the center of our knowledge banks and its most far-flung filaments. Together this whole elaborate structure begins to constitute something like the entirety of the information sphere. It becomes, as Novalis said, home.

With a few flicks of the finger, for example, I can determine that Voyager 1, the most distant artifact ever made by humanity, reset its "command loss timer" the other day. I can tell you how much propellant it has left, and the power levels of its generators. Voyager left the solar system more than a decade ago. It is nearly eight billion miles away. The spacecraft's EKG readings are so weak that the signal striking NASA's global network of deep-space antennas is only 10-16 watts—or one part in 10 quadrillion. A digital watch uses 20 billion times more power. Traveling at the speed of light, a signal from Voyager currently takes more than ten hours to reach Earth.

Later I will edit images, crop them, print them out. Coffee. Morning sunlight bounces off the snow. A Yugo buzzes by below the window like a fly. I see that were they created by individual human beings, some of these pictures of the solar system and the stars would be considered as much works of art as, for example, Ansel Adams's celebrated photographs of Yosemite, or Frederic Church's paintings of Niagara. But these depictions of nature are far wilder. I survey an intricate, storm-racked black-and-white Galileo mosaic—five joined pictures of Jupiter's immense hydrogen-cloud belts, stacked jaggedly in a kind of composite lightning bolt. It's a picture worthy of a planet named after the Roman ruler of the universe. It also brings to mind Leonardo's monochromatic Adoration of the Magi, never completed, which dominates a room in the Uffizi Gallery, in Florence. The three Wise Men gaze in amazement at the impossible child. Seated at the center, a serene anchor to the composition, the Madonna smiles enigmatically. Around them an inexplicable cosmos swirls: concentric whorls leading, finally, to a set of stairs reaching up and out—to the heavens.

In the apocalyptic gloom of Tarkovsky's last film, The Sacrifice, two characters peer anxiously at a framed reproduction of this same painting. Calling it "sinister," one of them confesses, "I've always been terrified of Leonardo." Seeking a reproduction of Adoration, I click my CD-ROM encyclopedia open to "Leonardo," and find this sentence: "His scientific theories, like his artistic innovations, were based on careful observation and precise documentation. He understood, better than anyone of his century or the next, the importance of precise scientific observation."

Ninety years after Leonardo's death Galileo turned his telescope to the sky—and our knowledge of the universe exploded. By the end of the seventeenth century the total number of known bodies in the solar system had more than doubled. Three hundred years later, near the end of its own life, Galileo's robot namesake continues to thread its way among the moons he discovered. The universe is exploding again.

I burn Galileo's depiction of Jupiter onto a CD—a procedure necessary because the file is so large—and take it to a place full of shiny new machines busy printing, with the methodical longitudinal whir of high-speed ink jets, big photo-quality images, mostly for advertising. The guy flicking switches there is so intrigued by this raging Jovian stormscape—not to mention my oddball reasons for wanting a poster-size copy of it—that he prints the picture out on a panel the size of a door and refuses to take money. Motoring back on Ljubljana's perilous ring road, I meditate on the fact that questions of authorship would tend to disqualify a space probe's pictures from serious consideration as works of art—even though its scientific discoveries are undeniable, and attributed. Yet those same questions are very much present in the rarefied art-world air these days. Even Ansel Adams was Ansel Adams only part of the time. Like most photographers, he shot a lot of pictures and then selected those few that today constitute the work we connect with his name. As for these deep-space images, they aren't really very different. It's just that they come from the confluence of an immense collective scientific and engineering effort and the stark, disturbing beauty of the cosmos itself. What's left is choice—curatorship.

And I would argue that these pictures qualify as art for another reason: their mysterious, Leonardo-esque smile. Who can fathom the mind-blowing idea that, just possibly, some rich, strange form of life may be swimming around under the frozen crust of Europa—a sphere itself in orbit around wrathful Jupiter? And what other way currently exists to leave Earth and look back at that glistening blue-white marble suspended in darkness, a diminishing place, a mote finally winking down to microscopic size and being replaced by a larger system of turning worlds? In this cosmic tracking shot it's not only space and time that are spanned but also the sum total of our homegrown sciences, philosophies, and arts, revealing, ultimately, a shower of sparks—the universe.

The jagged geometry of supersmooth Europa; the idiosyncratic surfaces of the other orbs floating serenely in space; the pristine interstellar vacuum; the inscrutable emptiness of intergalactic space, that immense, echoing, absolutely featureless void enveloping the spinning galaxies: it all serves as a perfect philosophical mirror image, reflecting back the quandary of the species, the limitations of human knowledge. The frail architecture defined by our distant tools, which places the human race at the center of "what's known," is actually our own map of ourselves—a chart that we'll hand down to successive generations, who may one day see a charming primitivism, or even an intriguing prescience, in our view of all that.

I park the car, tread through snowdrifts, and climb the complaining stairs. Galileo's rendition of Jupiter hangs above my desk in a beam of winter sunlight so feeble that it might be coming from some more distant star. Is this science, religion, or art? Or some kind of recombinant, millennial all-of-the-above? Maybe Leonardo's Madonna, poised superbly in front of the eroding topography of our particular sphere, is smiling because she knows the answers to those questions. Finally, though, what she might say is irrelevant. Because that ambiguity continues in the infinite landscapes beyond—up the staircase of an incomplete Adoration.